

## SPEED SONIC ACROSS THE SPAN: A PLATFORM AUDIO GAME

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### ABSTRACT

We describe the sound design and initial user study of an audio game created for gamers with visual impairments. Despite the wild popularity of platform games such as Super Mario [1] and the development of many audio games over the past decade, the platform genre has so far been all but ignored by audio game designers. To fill this gap and to add to the limited entertainment choices visually impaired gamers have, we developed a platform game that can be played via an audio-only interface. We conducted a study to test our game and audio design choices, to measure the users' performance and to find out if the game was fun to play. This usability study used 9 participants who played the game as a traditional video game (audio-visual input) and 9 participants who played the game as a pure audio game (audio-only input). The results show that, although it took the audio-only group considerably longer to play through the game, they did not make significantly more mistakes and they seemed to find the audio-only version challenging, yet enjoyable.

[Keywords: Audio Game, Game Design, Audio Cues, Spatial Sound, Auditory Icons, Accessibility]

### 1. INTRODUCTION

#### 1.1. Project and Motivation

Boarding schools exist throughout the United States to provide education for students with visual impairments. Teachers and administrators of these schools have bemoaned the fact that visually impaired students have few options to entertain themselves compared to fully sighted students. We initially discussed the lack of entertainment options with students and staff at the Indiana School for the Blind, and after a couple of focus group meetings with students we decided to make an audio game in the platform genre.

Conceptually, platform games are very simple — inside a 2D, side scrolling world, a player hops on or over objects, such as obstacles and platforms, to reach a goal [1]. We chose to create a platform audio game because several of the visually impaired users we spoke with had fond memories of playing the Super Mario Brothers video game, either by using their limited vision or by memorizing the layout of levels through trial and error [2].

Our primary goal was to create a platform game for visually impaired students to enhance their entertainment options and quality of life. This required us to investigate the difficult problem of representing the 2D spatial map inherent to platform

games via audio cues alone. Such maps do not translate easily to audio games because of the difficulty of creating good spatial audio cues. Not only did we have to create audio cues to represent the game's objects, but we also had to find methods to convey the spatial relationships (the height, the distance, and the length) of objects — which are critical relationships for the gameplay.

Besides the benefits to audio gamers, the results from this investigation may also be applied for some non-game applications, such as encoding spatial information (distance) into audio as part of a multi-modal information system or for use in virtual environments.

#### 1.1. Background: Audio Games

Audio games have been around for over a decade. Many "classic" games have been converted to audio games, such as Space Invaders and Doom [3,4]. In addition, guidelines have been written regarding the design of simple audio games [5].

The key issue for sound-based game design is to effectively represent game objects via audio cues. For example, objects can be represented by the kind of sound they would naturally make (called auditory icons), or be represented with an abstract sound (such as a simple piano chord, called earcons) [5,6,7]. Using the "natural connections" of auditory icons as opposed to more abstract auditory mappings of earcons thought to make it easier to recognize and remember the sounds since no new semantic links need to be learned [8]. However, for some types of game objects, such as pits (bottomless holes) and platforms (floors that can be walked on) there is no good natural audio cue. For these objects the only other option is to use abstract audio cues, which need to be taught to the user and need to be designed so that the user is able to remember them easily [5].

Currently available audio games run the gamut from simple memory games to first person shooters such as Shades of Doom [4, 5]. While games such as Shades of Doom and several others are fairly complex and require an understanding of spatial relationships, the majority of audio games are fairly simple maze or puzzle games. More complex games require that a more realistic spatial environment can be presented via audio; however the concept of distance (or spatiality) ultimately requires a 2D or 3D rendering of the sound and hence binaural cues. Without these binaural cues, relationships are difficult to determine [5].

Typical platform games require that multiple game objects and their positions are presented to the user while simultaneously allowing him or her to react to these objects in an instant, such as jumping over a moving enemy to reach a platform at a higher floor. This spatial context makes the design of audio cues particularly challenging. The only example of an audio platform

game that is currently available is Super Liam [9]. Super Liam uses simplified platform game rules by only having one platform without any higher platforms or pits that the user would have to jump to or jump over; therefore it can be played without requiring the user to learn complicated spatial audio cues [9].

## 1.2. Sound Design

Our game consists of four primary objects: the player (a representation of the user on the screen), platforms, enemies, and pits [Figure 1]. Each type of object has its own set of sounds and set of rules that it follows to convey its information to the user.

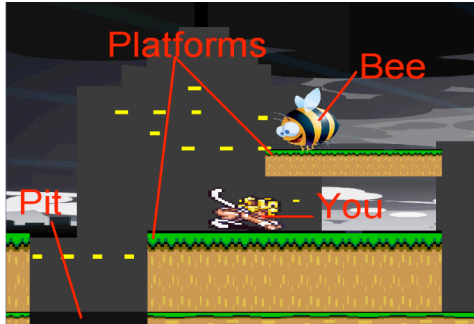


Figure 1. A screenshot of the game with the primary object labeled. The player is labeled “You”.

Table 1 lists the game objects and the methods used to convey their locations. The game has the player move through several game levels. The objective of each level in the game is to move to the right through the 2D game world until a certain location is reached - the player then starts at the next game level and moves again to the right. The player is always at a central position in the game. The relative positions of all other objects are rendered (via stereo panning) with regard to the player.

In our game the player can stand still, walk or jump. We indicate the player’s walk via footstep sounds. There are four floors at fixed elevations (called 1 to 4) that the player can walk on that correspond to the vertical placement of platforms [Figure 2]. When the player jumps, a pitched jump sound is played, which symbolically “draws” the curve of the jump via its sound. Jumps will always have the same maximum height - just enough to jump up one floor. Upon landing again on the ground, the user hears a pitched landing sound (drum) plus a *vocal cue*: a voice reading the current floor number (“one”, “two”, etc.). Using this vocal cue is meant to reduce the cognitive load on the user, who already has to focus on the spatial cues and react to impending dangers. The vocal cues are monosyllabic and are as short as a typical auditory icon or an earcon.

Platforms come in two sub-types: floating and solid platforms. The player can walk underneath floating platforms, but will run into a “wall” when approaching a solid platform forcing him/her to jump on top of it to continue. Jumping while under a floating platform will result in an “ow” sound when hitting the “ceiling”; running into the wall

of a solid platform will play a “d’oh” sound [Figure 3].

|                                | Voice (numbers) | Voice (icon) | Auditory Icon (Pitched, Panned) | Auditory Icon (Pitched) | Earcon (Pitched, Panned) |
|--------------------------------|-----------------|--------------|---------------------------------|-------------------------|--------------------------|
| <b>Player Jump</b>             |                 |              |                                 | X                       |                          |
| <b>Player Land</b>             | X               |              |                                 |                         | X                        |
| <b>Player Walk</b>             |                 |              |                                 | X                       |                          |
| <b>Floating Platform</b>       |                 | X            |                                 |                         | X                        |
| <b>Solid Platform</b>          |                 | X            |                                 |                         | X                        |
| <b>End Of Platform Warning</b> |                 |              |                                 |                         | X                        |
| <b>Pit</b>                     |                 |              |                                 |                         | X                        |
| <b>Bees</b>                    |                 |              | X                               |                         |                          |
| <b>Dogs</b>                    |                 |              | X                               |                         |                          |

Table 1: Primary objects in the game world and their auditory representations



Figure 2. The four floors used in the game for platforms.

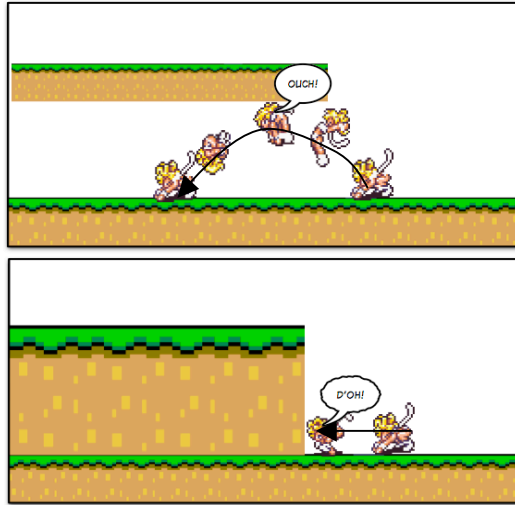


Figure 3. A cartoon showing a collision with floating platform (top) and with a solid platform (bottom).

We chose some of the sounds based on popular cultural cues (the jump sound from Super Mario Brothers, Homer's "d'oh" for running into an object, etc) to build on these existing semantic links for our target audience.

As there is no good semantic link for an approaching platform, we decided to design the sound as an earcon. The critical information for a player is whether an approaching platform could be jumped onto from the current position. We decided to use a deliberately simplified game world where a higher platform is always exactly one floor higher than the current position. However, we decided that it would be possible for the player to descend *one or more floors down* and safely land on a lower platform. In both cases, the new floor's number is conveyed via the vocal cue of the landing sound. This narrows down the needed information for any platform the player approaches to a) higher, b) lower and c) same floor (i.e. a simple gap)

The player uses a built-in directional sonar device to get information about the position of a platform ahead (How far away? Up or Down?). In order to "hear" the sound that is bounced off the platform, the player must be facing the platform. This sound contains information about the platform's distance and relative position.

To answer the "Up or down?" question we used a glissando modification of the platform sound: glissando up for a higher platform and glissando down for a lower platform. No glissando is used for a platform of equal elevation. To answer the "How far away?" question, the sound is panned left and right accordingly, with the sound in the center when the player is very close to the platform. Traveling any further at this point would result in being unable to reach the platform by jumping onto it as this would result in the player hitting the bottom of the platform [Figure 3]. In addition to the panning, the speed of platform sound's repetition and its loudness help the user decide when to jump – they both increase as the player approaches the platform's edge. A similar approach has been successful in auditory graph design [11].

In our initial pilot study we found that it was difficult to know when the end of a platform was close. We therefore added

a *platform-end warning* sound. We use a loud ding tone as our earcon, similar to the warning sound on Windows computers, to warn that the end of the current platform is approaching and that the player will either have to jump to another platform or fall to a lower platform [7]. Since the ding sound is already used by Windows to call for the user's attention, we hope to again leverage an already existing semantic link for this sound (although this will only work for Windows users) [9].

In order to make the game more enjoyable we introduced two elements designed to add a "danger factor" to the game. As typical for the platform genre, we decided to add obstacles: a pit and two "enemies".

The pit is always placed on floor 1 and forces the player to jump over it or fall into it and start the game level over. When the player approaches a pit, a panned organ sound is played. If the player is on floor 2 or higher when approaching the pit (on floor 1) the pit warning replaces the end of platform warning. An organ sound was chosen because its "spooky" tone might leverage a semantic link between a bottomless (dangerous) pit and the "spooky" organ sound often associated with Halloween and funerals.

Enemy objects need to be avoided as coming into contact with them will force the user to restart the game level. The enemy objects' sounds can be heard no matter which direction the player is facing. These sounds are again panned according to the location of the enemy - left when the enemy is left of the player and right when the enemy is on the right of the player. "Enemy" sounds also get louder as the player gets closer to them.

We use two types of enemies: bees and dogs. Bees only travel vertically—moving between the top of the game world and a platform. The bee makes a buzzing sound in order to enforce the semantic link that serves as an auditory icon [7]. The bee's sound is pitch shifted to indicate its relative elevation – listening to the bee's pitch rising and falling will allow the user to move the player under the bee (when it is at its highest point) or jump over it (when it is at its lowest point).

The dog enemy object only travels horizontally. Since determining the proper horizontal position of the dog is critical for the user in order to time the jump over it, the dog's distance is tied to the repetition speed of its bark. When the player gets within a certain horizontal (very close) range of the dog, the bark changes to a growl, telling the player to jump immediately or be bitten. The bark and growl tones were chosen because of their semantic links to dogs.

## 2. USER STUDY

In order to test our application, we conducted a user study consisting of 18 undergraduate and graduate students (8 males and 10 females). We worked with sighted participants but blindfolded half of them. The participants were randomly assigned to play either the *audio-only* version (blindfolded) or a traditional video-game version (*audio-visual*).

### 2.1. User Study Design

With a researcher present, participants first read the instructions from a Microsoft Word document with embedded sound files. The instructions were divided into several sections, each of which introduced a new game element. Guided by the instructions, the participants played through ten increasingly

complex training levels to familiarize themselves with the game mechanics and the audio cues. Participants in both groups played with a game controller and with headphones, however only the audio-visual group was able to see the game on a monitor. The participants read through the instructions at their own pace, played the sample sounds as often as they desired, and at the end of each section played through a training level that dealt with each newly introduced game element in isolation.

The participants then played through the seven levels of the actual game. The participants' game performance was scored based on the speed of level completion (faster being better) and the number of times they were sent back to the beginning of the level (more restarts being worse). After completing the main game, the participants filled out an exit survey in which they rated their ability to recognize the various objects, spatial relationships, etc. and generally commented on the game experience.

## 2.2. Results

We performed an ANOVA between the two groups using the answers from the questionnaires and the game performance data. In terms of relevant background experience that might affect their performance the analysis results showed no significant differences between the audio-only and the audio-visual participants or between males and females. Most participants played computer (video) games on occasion. All participants used computers very frequently, while only very few of the participants (17%) used programs where auditory signals provided the primary means of obtaining information (such as screen readers). Most participants had some familiarity with platform games.

We asked the participants about audio in computer games and they reported the following: 5% simply ignore the sounds; 61% use sound as an enhancement of the realism of the game, but they do not actually use it in a functional (guiding) way; 28% use sound to warn them of critical game events; such as an incoming attack; and 39% use sound to obtain spatial information (e.g. about enemies and objects behind them).

Most participants in both groups found the sounds for dogs, the bees and the pit very easy to identify, while the platform sounds were more difficult to recognize. This may have to do with the more abstract sounds assigned to platforms.

The majority of participants in the audio-only group indicated that they were able to determine both the vertical and horizontal location of objects via the sound (via pitch shift and via panning); however a few participants indicated problems with recognizing the vertical axis (pitch). Conversely, those in the audio-visual group found on average that the sound was beneficial for locating objects along the horizontal plane but not for locating objects along the vertical axis. This might indicate that the sound cues failed to provide any added benefit to what the players could already see on the screen.

Most of audio-only participants, and some audio-visual participants, also used audio cues in determining the distance, direction, height, and type of objects. However, it was also mentioned that audio cues did not help to determine the speed or length of objects, which is to be expected, given that we did not provide any dedicated cues for speed or length.

With regard to game performance, the number of restarts did not vary significantly between groups. The audio-visual participants needed a mean of 0.38 restarts ( $SD = 0.17$ ); audio-

only participants needed a mean of 0.76 restarts ( $SD = 0.18$ ). It took the audio-only group, on average, nearly three times as long to complete levels as the audio-visual group: participants in the audio-visual group needed a mean time of 36.54 seconds ( $SD = 5.05$ ), while participants in the audio-only group needed a mean level completion time of 102.34 seconds ( $SD = 5.73$ ). Whether this is due to their inexperience with audio interfaces or perhaps problems with using the auditory cues provided is unclear at this point.

## 3. CONCLUSION

This project allowed us to take what is graphically a very simple video game and translate it into a challenging audio game that is accessible to people with visual impairments and blind users. Despite the slightly modified platform game rules and, what to the participants in the blindfolded group must have been an unusual gaming experience, the majority of participants found the game enjoyable. Several participants from each of the groups asked to try out the alternative version of the game after completing the exit survey – many of the audio-visual users found the audio-only version to be more challenging and more enjoyable.

This not only shows that an audio game requiring complex 2D spatial relationships can be built and played with a relatively good success rate, but it also shows that audio games can also be enjoyed by sighted gamers. The audio techniques we used to create this 2D game may also be useful as a teaching tool for helping visually impaired students understand 2D maps and floor plans. It may be possible to apply some of our techniques to existing audio map projects that help the visually impaired with using spatial orientation (such as the BATS project[12]).

We are currently repeating this study with visually impaired and blind participants to see how their performance of the audio-only version compares to that of sighted participants (our audio-only group). Besides some accommodations, such as assisting the participants with reading the instructions, playing the example sound files and filling out the questionnaires, the procedure is the same as for the audio-only group. As the participants with visual impairments are likely to have day-to-day experience with auditory interfaces, a comparison of their results with the results from our current study may help us determine if the difference between the speed of completion between our audio-only group and our audio-visual group may be the result of lack of experience with auditory interfaces on the part of the audio-only group. We will also allow the visually-impaired participants to play the game for several weeks and solicit their feedback after this time. This will determine if our game is indeed an enrichment of the entertainment options for visually impaired students.

## 4. REFERENCES

1. Platform Games, Wikipedia.  
[http://en.wikipedia.org/wiki/Platform\\_game](http://en.wikipedia.org/wiki/Platform_game).
2. Super Mario Bros., Wikipedia.  
[http://en.wikipedia.org/wiki/Super\\_Mario\\_BrosM.R](http://en.wikipedia.org/wiki/Super_Mario_BrosM.R).
3. McCrindle, R.J., Symons, D. Audio Space Invaders. In Proc. Intl Conf. Disability, Virtual Reality, & Assoc. Technology, University of Reading, UK (2000), 59-65.
4. Shades of Doom. <http://www.gmagames.com/sod.html>.

5. Gärdenfors, Dan. Designing Sound-Based Computer Games. In *Cybersonica Symposium* (2002), 1-7.
6. Gaver, William W., Norman, Donald A. Everyday listening and auditory icons, Ph.D. Dissertation, University of California, San Diego, 1988.
7. Blattner, M. M.; Sumikawa, D.A.; & Greenberg, R.M. "Earcons and Icons: Their Structure and Common Design Principles." *Human-Computer Interaction*, 4, 11-44. ACM Press: 1989.
8. Brewster, Stephen; Wright, Peter; and Edwards, Alistair. "An Evaluation of Earcons for Use in Auditory Human-Computer Interfaces". *INTERCHI '93*. ACM Press: 1993.
9. Super Liam, AudioGames.net.  
<http://www.audiogames.net/db.php?action=view&id=superliam>.
10. Mansur, Douglass; Blattner, Meera; and Joy, Kenneth. "Sound Graphs: A Numerical Data Analysis Method for the Blind". *Journal of Medical Systems*, Vol. 9, No. 3: 1985.
11. Flowers, John. "Thirteen Years of Reflection on Auditory Graphing: Promises, Pitfalls, and Potential New Directions". *ICAD '05*. Limerick, Ireland: July 6-9, 2005.
12. BATS, University North Carolina.  
<http://www.cs.unc.edu/Research/assist/bats/features.shtml>